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VARIATION IN PERFORMANCE OF A HISPANO-SUIZA (MODEL E) ENGINE WITH DEGREE OF THROTTLE OPENING

(POWER PLANT SECTION REPORT)

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VARIATION IN PERFORMANCE OF A HISPANO-SUIZA (MODEL E) ENGINE WITH DEGREE OF THROTTLE OPENING.

OBJECT OF TEST.

The object of this test was to determine the variation in performance of a Hispano-Suiza (model E) engine with degree of throttle opening at various engine speeds.

CONCLUSIONS.

The power output obtained at given throttle openings over the entire speed range of the engine is shown by the curves in figure 1. The specific fuel consumptions are shown by the curves in figure 2. Actual test data are given in Table 1. The performance data corrected to even speeds are given in Table 2.

These data and the curves show the variation in performance of a Hispano-Suiza (model E) engine with degree of throttle opening at various engine speeds.

INTRODUCTION.

The Airplane Section of the Engineering Division, in order to make certain estimates of engine performance, wanted to determine the power output obtained on a typical airplane engine at given throttle openings over the entire speed range.

Two sets of runs were made on a Liberty "12" engine. It was found that at small throttle openings at any given speed, with the throttle securely locked in position, the manifold vacuum and the power fluctuated over a considerable range. The data for the tests on the Liberty engine are not included in this report as some variable, perhaps snow in the intake header, prevented a reliable determination of the engine's performance.

Reliable data were obtained on the Hispano-Suiza engine by using an intake air heater to maintain the temperature of the air supplied to the carburetor at approximately 95° F. It was possible to reproduce given conditions and check the performance within the limits of experimental error.

METHOD OF TEST.

Figures 3 and 4 show the installation of the Hispano-Suiza (model E) engine on the Sprague electric dynamometer. The method of connecting the carburetor to the intake air heater is clearly shown in the illustrations. The temperature of the air supplied to the carburetor was held at approximately 95° F. by controlling the amount of current supplied to the resistance coils of the air-heating element.

The following runs were made: [1]

(1) At full throttle, one power run from 800 revolutions per minute to 2,000 revolutions per minute, inclusive, in increments of 200 revolutions per minute.

(2) At the normal speed of 1,800 revolutions per minute, the throttle was gradually closed until 90 per cent of the full power was obtained. At this point the throttle was locked with a clamp and a set of power readings were obtained at the same speeds as indicated above.

(3) The general procedure outlined in paragraph (2) was repeated for throttle openings to give 80, 70, 60, 50, 40, 30, 20, and 10 per cent of the full power at the normal speed of 1,800 revolutions per minute. As the throttle was closed the speed at which the readings were started was lowered to 600 revolutions per minute.

(4) A friction run was made at each of the throttle openings and over the same speed range.

For method of taking readings and making the simpler standard computations, see Engineering Division Report Serial No. 1507.

The data tabulated in Table 2 was obtained in the following manner. The brake horsepower and the brake specific fuel consumption were obtained by reading the values directly from the curves at the intercepts of the even-speed ordinates. These curves are to be found in figures 1 and 2. The friction horsepower values were obtained in the same manner from curves plotted in pencil but not included in this report. The indicated horsepower was obtained by adding the brake and friction horsepowers. The mechanical efficiency was obtained by dividing the indicated into the brake horsepower. All the mean effective pressures were obtained by computation from the corresponding horsepowers. The indicated specific fuel consumption was obtained by multiplying the brake specific fuel consumption by the mechanical efficiency.

ANALYSIS.

The temperature of the air supplied to the carburetor was readily maintained at 95° F. At any engine speed for any given throttle opening the manifold vacuum and the power output checked with readings taken previously under the same conditions of speed and throttle opening.

It was observed that the operation of the engine with the mixture control set for best power was not as smooth as with a richer mixture and a slightly lower power.

All of the curves of brake horsepower output at partial throttle, figure 1, appear to merge into the full power curve at the lower engine speeds. That is, at 600 revolutions per minute approximately the same power is obtained at practically any throttle opening. The peak of each curve is reached at a lower speed with each decrease in throttle opening.

The specific fuel consumption curves, figure 2, show an increase in fuel consumption at the normal speed as the throttle is closed. There appears to be very little difference in specific fuel consumption at the lower engine speeds at the various throttle openings.

The friction horsepower (which includes the pumping losses) increases slightly for a given engine speed at the smaller throttle openings. This is particularly noticeable at the lower engine speeds. See Table 2.

[1] During each run and at each speed the mixture control was adjusted for maximum fuel economy consistent with maximum power and smooth operation.

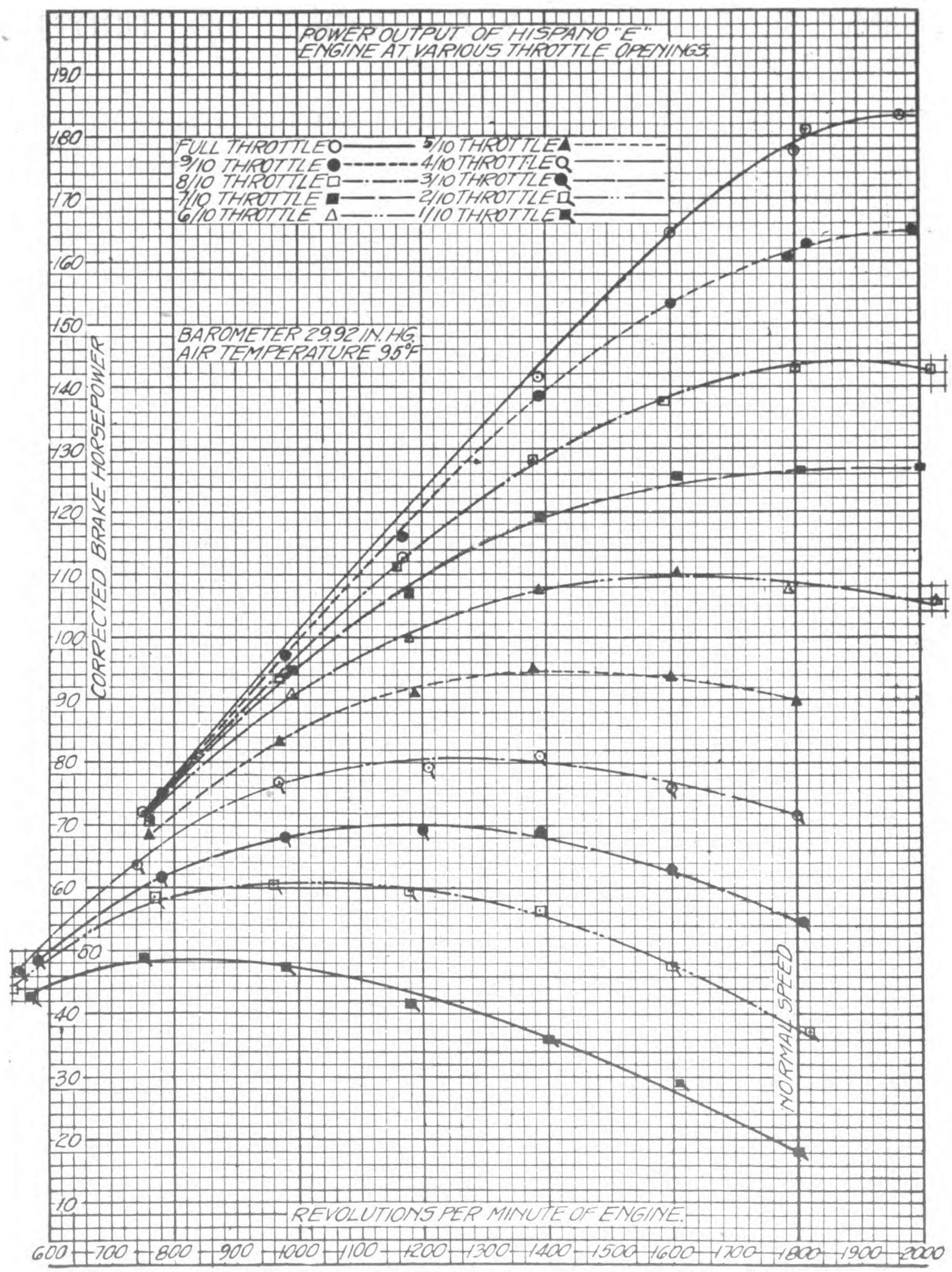
POWER OUTPUT OF HISPANO "E" ENGINE AT VARIOUS THROTTLE OPENINGS.
FULL THROTTLE
9/10 THROTTLE
8/10 THROTTLE
7/10 THROTTLE
6/10 THROTTLE
5/10 THROTTLE
4/10 THROTTLE
3/10 THROTTLE
2/10 THROTTLE
1/10 THROTTLE
BAROMETER 29.92 IN. HG.
AIR TEMPERATURE 95°F
CORRECTED BRAKE HORSEPOWER
NORMAL SPEED
REVOLUTIONS PER MINUTE OF ENGINE.
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000

FIG. 1.

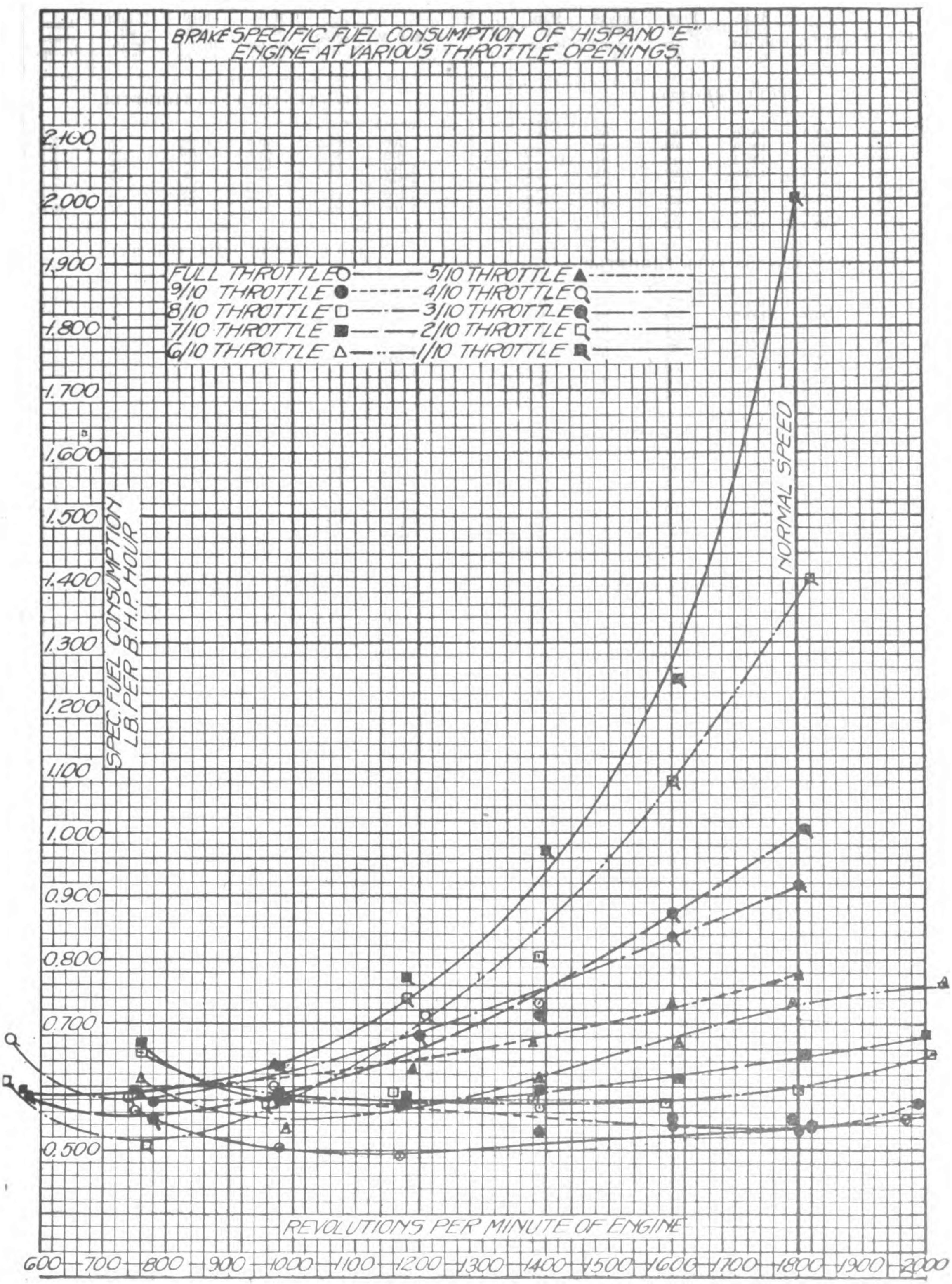

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FIG. 2.

TABLE 1.—*Actual test data.*

R. P. M.	Corrected B. H. P.	B. M. E. P. lb. per sq. in.	Fuel cons. lb. per hp. hr.	Intake air temp. °F.	Man. vac. in. hg.
FULL THROTTLE.					
750	72.0	106.0	0.562	95	0.3
980	94.1	106.0	.503	95	.5
1,170	122.7	106.3	.489	94	.7
1,390	141.6	112.3	.567	95	1.1
1,600	164.6	113.5	.538	95	1.5
1,800	177.7	108.9	.529	94	1.7
1,820	181.0	109.8	.536	94	1.7
1,970	183.5	102.8	.550	95	1.9
NINE-TENTHS FULL THROTTLE.					
780	75.2	106.3	0.577	94	0.8
980	96.7	109.0	.579	95	1.5
1,170	115.9	109.3	.571	95	1.9
1,390	138.3	109.7	.527	95	2.6
1,600	153.3	105.4	.549	95	3.1
1,820	162.7	98.8	.539	94	3.5
1,790	160.6	99.1	.550	95	3.6
1,990	165.0	91.6	.574	96	4.0
EIGHT-TENTHS FULL THROTTLE.					
760	70.6	102.6	0.654	95	1.5
970	93.8	106.7	.574	95	2.3
1,160	111.3	105.8	.592	95	3.1
1,380	128.2	102.6	.580	95	3.9
1,590	137.8	95.7	.574	95	4.8
1,800	143.0	87.7	.596	95	5.6
2,010	142.4	78.2	.654	94	6.3
SEVEN-TENTHS FULL THROTTLE.					
760	70.6	102.6	0.667	97	1.9
990	94.4	105.2	.579	96	2.9
1,180	107.2	100.3	.586	94	3.8
1,390	119.2	94.7	.596	95	4.8
1,610	125.8	86.2	.615	95	5.7
1,810	126.4	77.1	.652	95	6.7
2,000	127.1	70.2	.682	86	7.4
SIX-TENTHS FULL THROTTLE.					
760	71.1	103.3	0.614	96	2.6
990	90.6	101.1	.535	95	3.8
1,180	99.9	93.5	.578	95	5.0
1,390	107.7	85.6	.613	95	6.2
1,610	110.3	75.6	.667	95	7.2
1,790	107.6	66.4	.733	94	8.2
2,030	105.8	57.7	.764	94	9.3

TABLE 1.—*Actual test data*—Continued.

R. P. M.	Corrected B. H. P.	B. M. E. P. lb. per sq. in.	Fuel cons. lb. per hp. hr.	Intake air temp. °F.	Man. vac. in. hg.
FIVE-TENTHS FULL THROTTLE.					
760	68.2	99.1	0.582	95	3.3
970	83.3	94.9	.636	95	4.9
1,190	91.1	84.5	.625	95	6.3
1,390	94.7	75.8	.670	95	7.5
1,600	93.7	64.7	.730	94	9.0
1,800	89.8	55.1	.777	95	10.0
FOUR-TENTHS FULL THROTTLE.					
550	46.7	93.8	0.673	95	2.7
740	63.6	94.9	.585	95	4.2
970	76.6	87.2	.599	95	6.1
1,210	79.2	72.4	.712	94	8.1
1,390	80.9	64.3	.730	95	9.4
1,600	76.0	52.4	.838	95	10.7
1,800	71.7	44.0	.915	94	11.7
THREE-TENTHS FULL THROTTLE.					
580	48.3	91.9	0.582	95	3.6
780	61.7	87.3	.547	95	5.5
980	68.0	76.6	.593	95	7.5
1,200	69.1	63.6	.680	94	9.4
1,390	69.0	54.7	.711	95	10.9
1,600	62.7	43.3	.875	96	12.3
1,810	54.6	33.3	1.019	95	13.4
TWO-TENTHS FULL THROTTLE.					
540	44.0	90.0	0.610	95	4.0
770	58.5	83.9	.508	95	6.6
960	60.3	69.3	.573	96	8.6
1,180	59.7	55.9	.740	97	10.9
1,390	56.4	44.8	.806	94	12.5
1,600	47.8	33.0	1.082	95	13.8
1,820	37.3	22.6	1.401	96	14.9
ONE-TENTH FULL THROTTLE.					
570	42.8	82.7	0.599	95	6.0
750	48.6	71.6	.598	96	8.8
980	47.6	53.6	.632	95	11.6
1,180	41.7	39.0	.773	94	13.4
1,400	35.9	28.3	.974	95	14.9
1,610	29.0	19.9	1.242	95	16.0
1,800	18.1	11.1	2.005	95	16.7

TABLE 2.—*Performance data corrected to even speeds.*

R. P. M.	Horsepower.			Mech. Eff. %	Mean effective press. lb. per sq. in.			Specific fuel cons. lb. per hp. hr.	
	Brake.	Friction.	Indicated.		Brake.	Friction.	Indicated.	Brake.	Indicated.
FULL THROTTLE.									
800	78.0	5.1	83.1	93.9	107.6	7.0	114.6	0.540	0.507
1,000	101.0	8.0	109.0	92.7	111.5	8.8	120.3	.500	.464
1,200	123.3	10.8	134.1	92.1	113.3	9.9	123.2	.498	.458
1,400	144.5	14.9	159.4	90.7	113.8	11.8	125.6	.510	.463
1,600	164.4	19.2	183.6	89.6	113.4	13.2	126.6	.522	.467
1,800	179.0	24.0	203.0	88.2	109.7	14.7	124.4	.535	.472
2,000	183.2	30.7	213.9	85.6	101.0	16.9	117.9	.555	.475
NINE-TENTHS FULL THROTTLE.									
800	77.7	5.3	83.0	93.6	107.2	7.3	114.5	0.579	0.542
1,000	99.6	9.3	108.9	91.4	109.9	10.3	120.2	.580	.530
1,200	120.5	12.0	132.5	91.0	110.7	11.0	121.7	.564	.513
1,400	139.3	15.4	154.7	90.1	109.8	12.1	121.9	.550	.495
1,600	153.3	19.2	172.5	88.9	105.7	13.2	118.9	.539	.479
1,800	161.7	22.8	184.5	87.6	99.1	14.0	113.1	.558	.471
2,000	165.0	29.3	194.3	84.9	91.3	16.2	107.5	.580	.492

TABLE 2.—*Performance data corrected to even speeds*—Continued.

R. P. M.	Horsepower.			Mech. Eff. %	Mean effective press. lb. per sq. in.			Specific fuel cons. lb. per hp. hr.	
	Brake.	Friction.	Indicated.		Brake.	Friction.	Indicated.	Brake.	Indicated.
EIGHT-TENTHS FULL THROTTLE.									
800	77.0	6.4	83.4	92.3	106.2	8.8	115.0	0.632	0.583
1,000	97.0	9.0	106.0	91.5	107.0	9.9	116.9	.586	.536
1,200	114.9	11.6	126.5	90.9	105.7	10.7	116.4	.576	.524
1,400	128.7	15.4	144.1	89.3	101.3	12.1	113.4	.573	.511
1,600	138.5	19.2	157.7	87.9	95.5	13.2	108.7	.580	.509
1,800	143.3	24.0	167.3	85.7	87.8	14.7	102.5	.600	.514
2,000	142.8	30.7	173.5	82.3	78.8	16.9	95.7	.650	.535
SEVEN-TENTHS FULL THROTTLE.									
800	76.5	6.9	83.4	91.8	105.5	9.5	115.0	0.635	0.583
1,000	95.2	9.0	104.2	91.4	105.0	9.9	114.9	.579	.529
1,200	109.5	11.6	121.1	90.5	100.6	10.7	111.3	.577	.522
1,400	119.0	15.4	134.4	88.5	93.8	12.1	105.9	.590	.522
1,600	124.0	19.7	143.7	86.3	85.6	13.6	99.2	.615	.531
1,800	126.5	24.0	150.5	84.1	77.6	14.7	92.3	.644	.541
2,000	127.0	32.0	159.0	79.9	70.1	17.7	87.8	.680	.543
SIX-TENTHS FULL THROTTLE.									
800	75.6	6.9	82.5	91.7	104.3	9.5	113.8	0.590	0.541
1,000	91.0	9.0	100.0	91.0	100.4	9.9	110.3	.550	.501
1,200	101.3	12.0	113.3	89.4	93.2	11.0	104.2	.570	.510
1,400	107.7	16.3	124.0	86.8	84.8	12.9	97.7	.619	.537
1,600	109.7	20.3	130.0	84.3	75.7	14.0	89.7	.679	.572
1,800	108.7	24.6	133.3	81.5	66.6	15.1	81.7	.728	.593
2,000	105.4	32.7	138.1	76.4	58.2	18.0	76.2	.756	.577
FIVE-TENTHS FULL THROTTLE.									
800	71.8	6.9	78.7	91.2	99.1	9.5	108.6	0.600	0.547
1,000	85.0	9.3	94.3	90.1	93.8	10.3	104.1	.616	.555
1,200	92.2	12.4	104.6	88.1	84.8	11.4	96.2	.642	.565
1,400	94.6	16.8	111.4	84.9	74.5	13.2	87.7	.680	.577
1,600	93.5	20.8	114.3	81.9	64.5	14.3	78.8	.721	.589
1,800	90.0	25.2	115.2	78.1	55.1	15.5	70.6	.780	.609
FOUR-TENTHS FULL THROTTLE.									
600	52.0	4.4	56.4	92.2	95.7	8.1	103.8	0.620	0.572
800	68.2	7.2	75.4	90.4	93.8	9.9	103.7	.585	.529
1,000	77.3	9.7	87.0	88.8	85.3	10.7	96.0	.625	.555
1,200	80.6	12.8	93.4	86.3	74.1	11.8	85.9	.683	.588
1,400	80.0	17.3	97.3	82.2	63.1	13.6	76.7	.755	.620
1,600	76.9	21.3	98.2	78.3	53.0	14.7	67.7	.835	.654
1,800	71.6	25.8	97.4	73.5	43.9	15.8	59.7	.912	.671
THREE-TENTHS FULL THROTTLE.									
600	50.0	4.4	54.4	91.9	92.0	8.1	100.1	0.575	0.529
800	62.4	7.2	69.6	89.7	86.1	9.9	96.0	.558	.501
1,000	68.5	10.3	78.8	86.9	75.6	11.4	87.0	.590	.513
1,200	70.0	13.2	83.2	84.1	64.4	12.1	76.5	.660	.555
1,400	68.0	17.7	85.7	79.3	53.6	14.0	67.6	.752	.596
1,600	62.4	22.4	84.8	73.6	43.0	15.5	58.5	.870	.640
1,800	55.0	27.0	82.0	67.1	33.7	16.6	50.3	.999	.671
TWO-TENTHS FULL THROTTLE.									
600	48.6	5.0	53.6	90.7	89.4	9.2	98.6	0.560	0.508
800	58.5	7.7	66.2	88.4	80.8	10.7	91.5	.520	.460
1,000	60.8	10.7	71.5	85.0	67.1	11.8	78.9	.581	.494
1,200	59.8	13.6	73.4	81.5	55.0	12.5	67.5	.700	.571
1,400	55.3	18.2	73.5	75.3	43.6	14.3	57.9	.860	.647
1,600	48.0	22.9	70.9	67.7	33.1	15.8	48.9	1.080	.731
1,800	37.6	27.6	65.2	57.7	23.1	16.9	40.0	1.366	.788
ONE-TENTH FULL THROTTLE.									
600	44.5	5.0	49.5	89.9	81.9	9.2	91.1	0.590	0.531
800	48.5	8.5	57.0	85.1	66.9	11.8	78.7	.597	.508
1,000	47.0	11.3	58.3	80.6	51.9	12.5	64.4	.642	.517
1,200	42.9	14.8	57.7	74.4	39.4	13.6	53.0	.750	.558
1,400	36.2	18.7	54.9	65.9	28.5	14.7	43.2	.940	.619
1,600	27.9	23.5	51.4	54.3	19.2	16.2	35.4	1.265	.687
1,800	18.0	28.2	46.2	39.0	11.0	17.3	28.3	2.000	.780

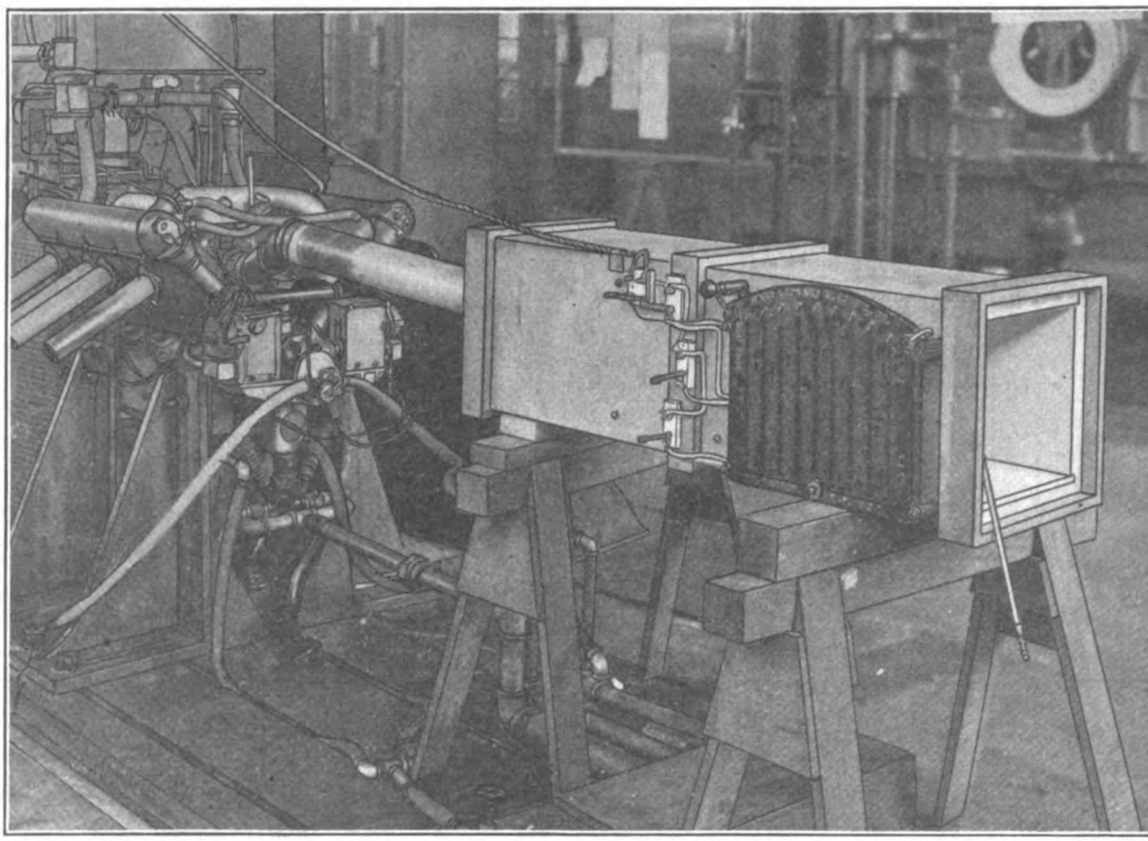

FIG. 3.—Installation on the dynamometer showing intake air heater connected to engine.

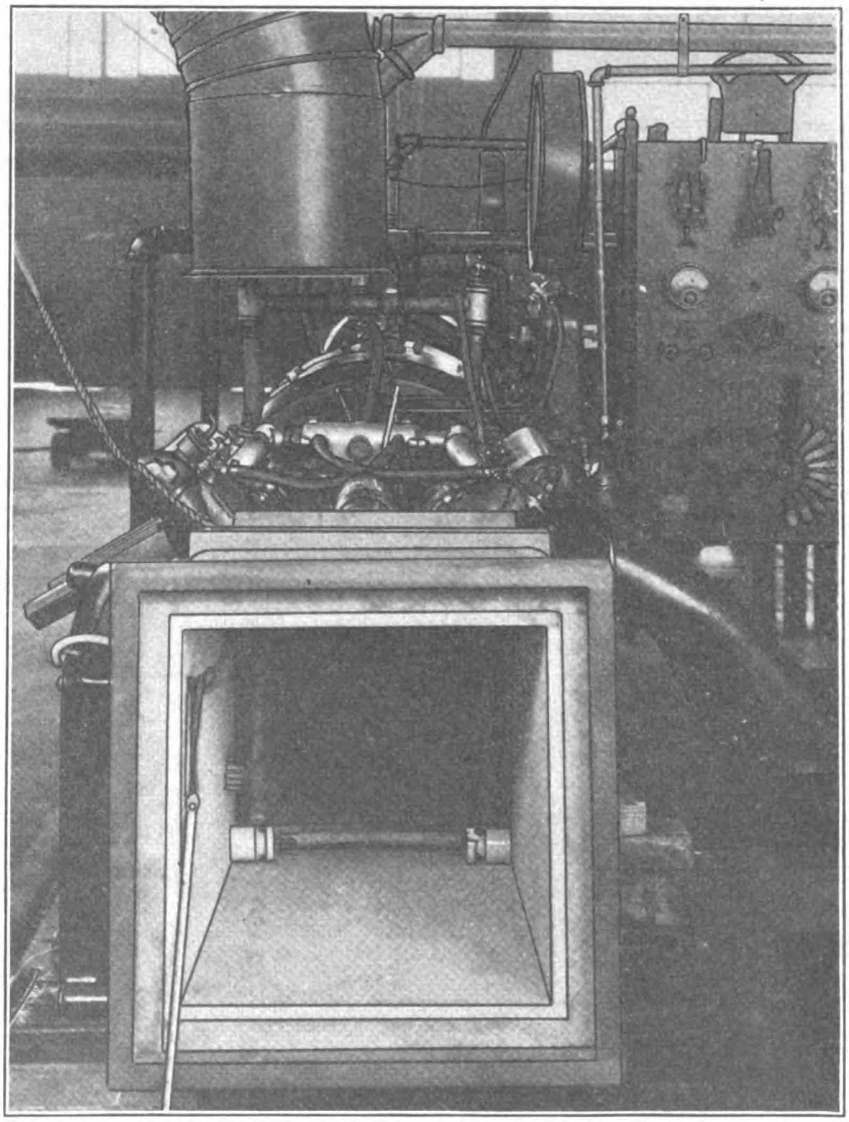

FIG. 4.—Installation on the dynamometer showing resistance coils.

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